Energy Storage in Photovoltaic Applications

John Boyes, Manager
Energy Storage and Distributed Energy Resources
Sandia National Laboratories*

*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000

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Contents of Presentation

1. Energy Storage Technologies
2. PV Applications Requiring Storage
3. PV Battery Life Issues
4. New Application Examples

Batteries

- Ni-Cad
- Li-ion
- Ni-metal hydride
- Zn-Br flow
- Lead-acid
  - Flooded
  - Valve-regulated

Alternate Storage Technologies

Pumped Hydro

Flywheels

SMES

Ultracaps

Compressed Air

Hydrogen

PV Applications Requiring Storage

Standalone

- Remote sensing
- Remote residential
- Microgrids
- ***All*** but water pumping

Grid-tied

- Peak shaving
- Grid stabilization
- All requiring ***dispatch***

Battery Impacts System Life-Cycle Cost (LCC)

- Initial Cost: $100 to $150/kWh
- Battery life-cycle costs for PV systems start at about 33% of the initial system cost
- Battery life-cycle costs alone can be over $1/kWh
- Under ideal circumstances battery life-cycle costs are about $0.35/kWh
- In many PV systems the battery is the most costly item over the life of the system

System Issues Reduce PV Battery Life (~ 5+ Years)

- Overdischarge
- Incomplete Recharge
- Temperature

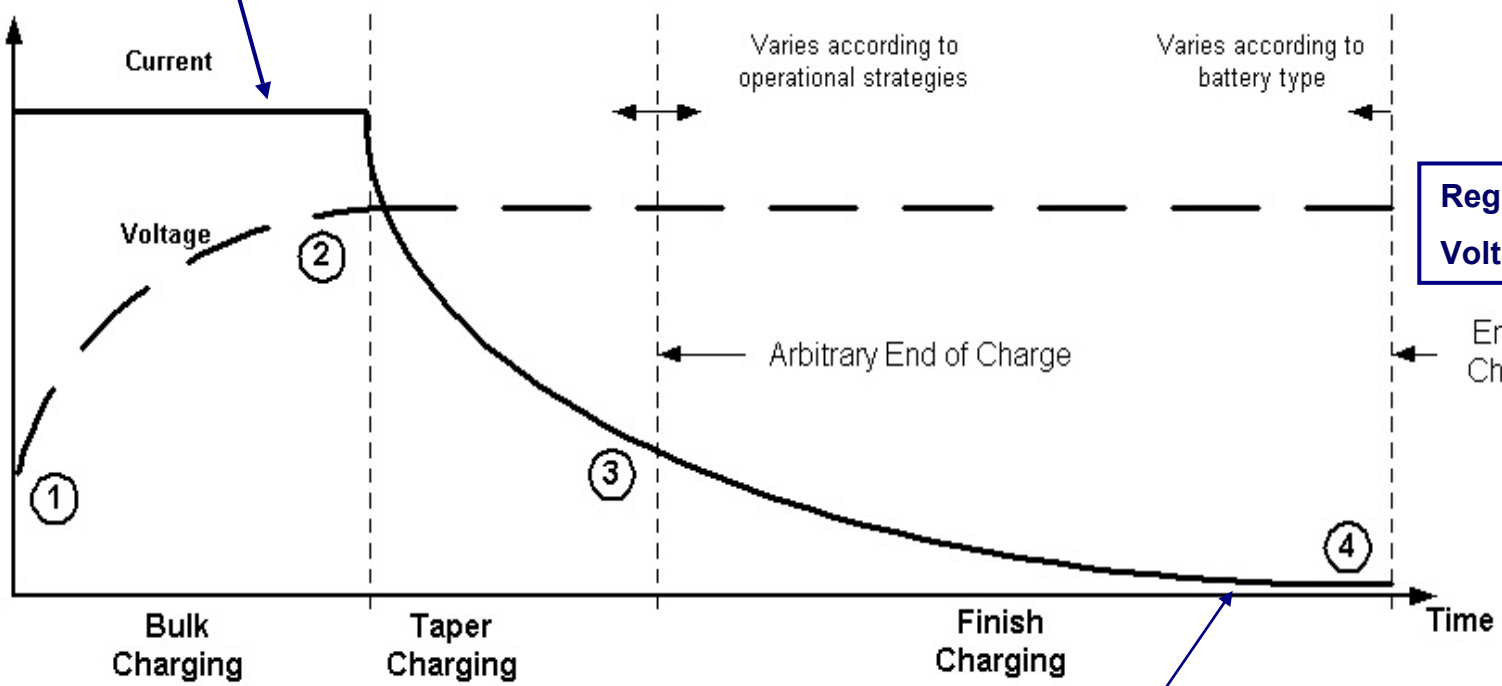
Causes:

- System Design (Array/Load)
- Improper charging (float vs. cycling)
- Operation (engine shut down)
- Maintenance (clean, water, torque)

PV-Hybrid System

Engine-Generator Charge

- Good charge acceptance
- High power = best engine efficiency



- Poor charge acceptance
- Lots of electrolysis
- Low power = poor engine efficiency
- Necessary to fully recharge

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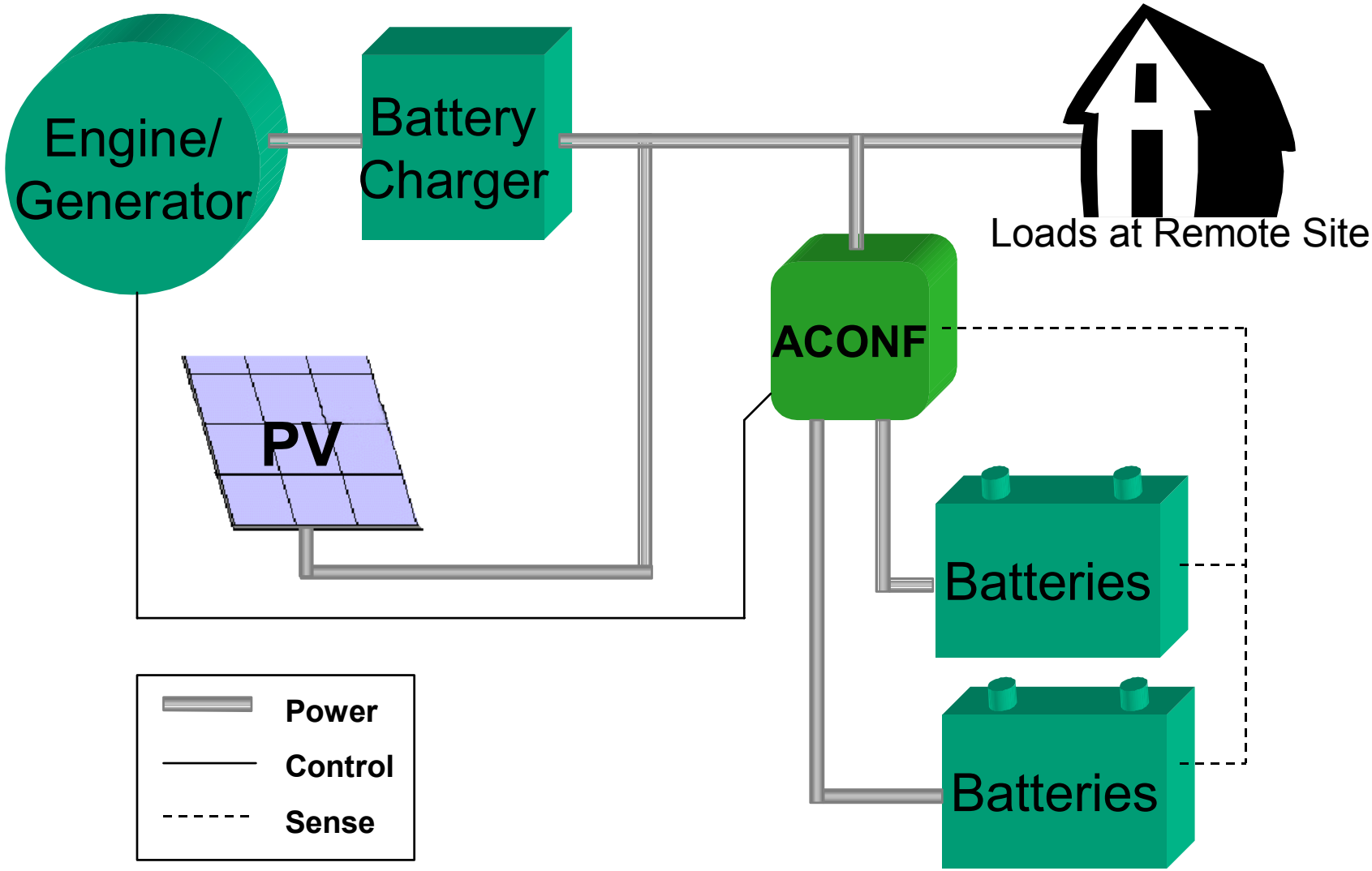
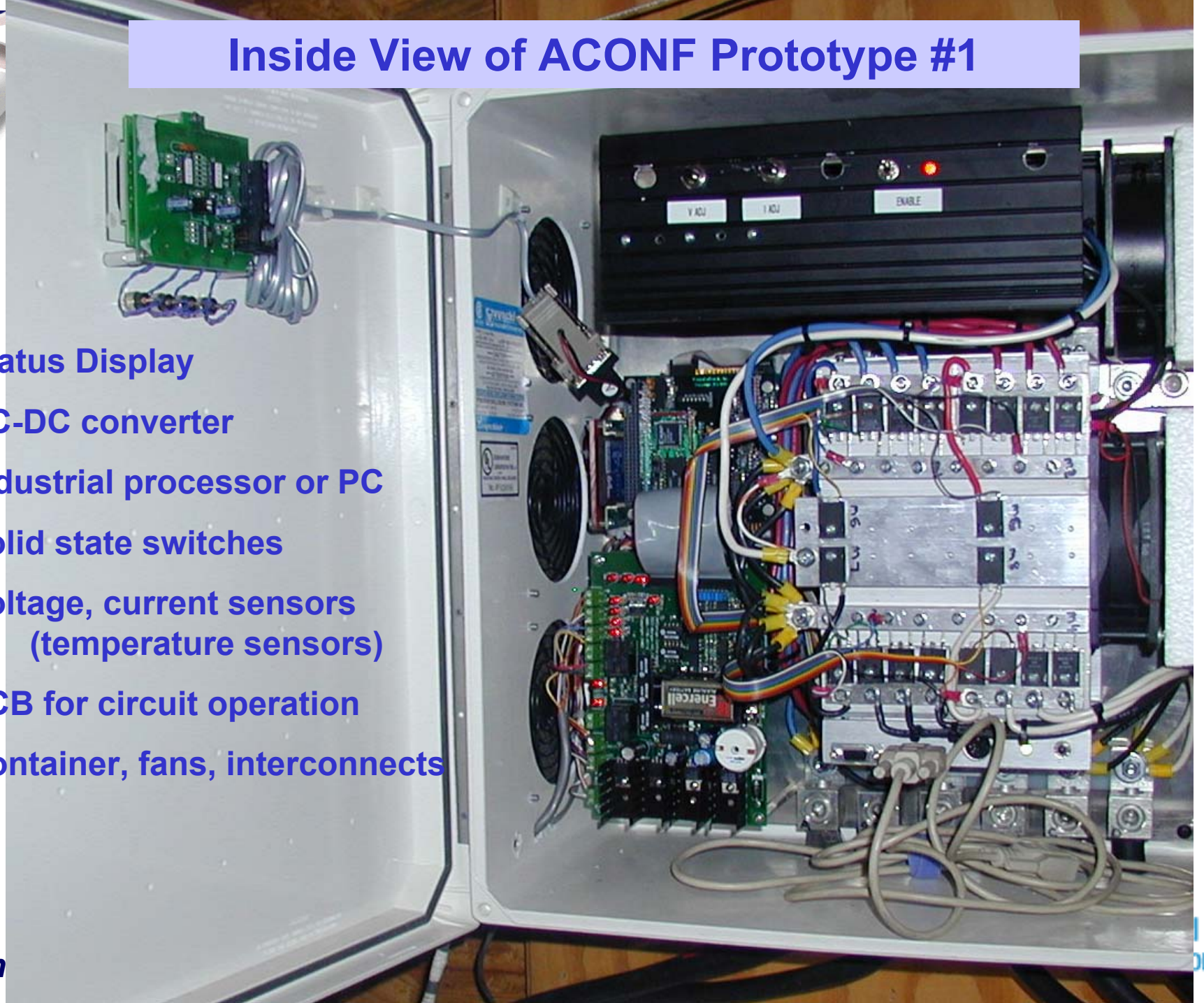
ACONF in Hybrid DC Power System



What Does ACONF Do?

- Cuts generator run time
  - Bulk charge ends shortly after regulation voltage is reached
  - Finish charge with ACONF rather than generator
  - Utilize potentially spilled solar during finish charge periods
- Reduce fuel use
  - Generator runs at more efficient operating point
- Improve battery management
  - Finish charge to smaller termination current
  - Tight voltage and current controls applied
  - Battery performance (life) expected to improve significantly
- Three units being successfully operated in simulated field tests (STAR, DETL)

Inside View of ACONF Prototype #1



- Status Display
- DC-DC converter
- Industrial processor or PC
- Solid state switches
- Voltage, current sensors (temperature sensors)
- PCB for circuit operation
- Container, fans, interconnects

US Coast Guard NDS Remote Hybrid Power Application

- National Distress System (NDS) sites
  - Currently 24 active sites along West Coast & Alaska
  - Rescue 21 program will double number of sites
- Sites used for study
  - Robert Barron site: 460 watts, 19 amps
  - Duke Island site: 350 watts, 14.4 amps
- Power system consists of following
  - PV array providing some of annual energy requirements
  - Propane generator with charger: 160 amps
  - Absolyte IIP Battery: Two 24V strings of 1065Ah cells
  - Controls, limited data acquisition

DETL Microgrid

Grid

480V Microgrid

Secure
SCADA Lab

Distributed
Energy
Resources

Loads
(Various)

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Microgrids Address Energy Surety

- Potential Microgrid Advantages
  - Diversity: fuel, resources
  - Reduce single-point vulnerabilities
  - Physical security/controls
- Military Base and Civilian Assessments Underway
- Require Standalone Operation (ENERGY STORAGE)

Greenpoint Manufacturing & Design Center

Joint Project of PowerLight and ZBB

Sponsored by

US DOE, Sandia, NYSERTA and
Clean Air Communities

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Greenpoint PV Project

- Choose PowerLight Solar Roof Panels to Reduce Operating Costs
- Installation of 115kW on 11,500 square feet of Unused Roof Space Was Completed in 10/2002

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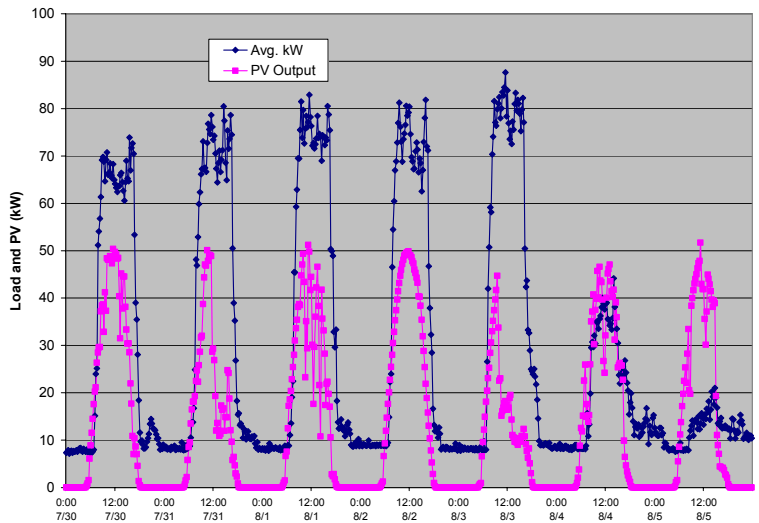
Battery Energy Storage Will Be Added in Late 2003

- Solar is Used as Generated on Weekdays
- Weekend Energy Must Be Shed as Utility Will Not Allow it to be Feed back into Grid. If Storage Available, Weekend Energy Can Be Used on Monday
- Storage Can Be Used on Weekdays to Peak Shave



Solar Generation vs. Energy Use for a Typical Week at Greenpoint Facility

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Battery Energy Storage System

- Zinc Bromine Flow Battery Manufactured by ZBB and SatCon
- Two Racks Rated at 25kW/50kWh each
- Factory Testing is Complete
- Installation Planned for Late 2003

Conclusion

- Many PV Applications Require Storage
- New technologies being developed
- Lead-acid batteries most cost-effective
- Attention to system issues:
  - extends battery life
  - reduces Life Cycle Cost

Workshop

Systems Driven Approach
for
Solar Applications of Energy Storage

November 5th and 6th
Maritime Institute, Baltimore MD

John Boyes: (505) 845-7090, jdboyes@sandia.gov

Jerry Ginn: (505) 845-9117, jwginn@sandia.gov

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